



Assessment of Technical Quality of 9562 Endodontic Cases Treated by Undergraduate Students and Endodontics Specialists

Avaliação da qualidade técnica de 9562 casos endodônticos tratados por estudantes de graduação e especialistas em endodontia

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ABSTRACT

Objective: The aim of the study was to assessment of technical quality of 9562 endodontic cases treated by heterogeneous groups with different clinical experience.

Material and methods: This retrospective study reviewed the dental records of 8590 patients (9562 endodontic cases and 13203 root canals including 3340 retreatment root canals) treated by fourth-year undergraduates, fifth-year undergraduates, endodontic program students, and endodontic specialists between December 2017 and December 2018 at the Department of Endodontics of Necmettin Erbakan University Faculty of Dentistry in Konya. The length, density, and taper of root fillings, the acceptable technical quality of the root filling criteria, and the presence of procedural errors, were recorded. Chi-square tests with a significance level at $p=0.05$ were used for statistical analysis.

Results: Acceptable root fillings were found in 71.5% of endodontic cases. Clinical experience showed statistical differences in the root filling quality among fourth-year undergraduates, fifth-year undergraduates, endodontic program students, and specialists (52, 63.1, 77.9 and 86.5% respectively). Fractured instruments and missed canals were noted in 9.8% and 0.57% of cases treated by endodontic program students significantly more than the other clinical experiences. No statistical differences were found among the clinical experiences in other procedural errors. No statistically significant differences were found between age range and gender in additional root canals. Statistically significant differences were observed between the number of root canal retreatments in terms of age range and gender.

Conclusions: Clinical experience affects the technical quality of root canal treatments. Fractured instruments and missed canals, especially by endodontic program students, should be given more attention.

KEYWORDS

Dental radiography; education; undergraduate.

RESUMO

Objetivo: O objetivo do estudo foi avaliar a qualidade técnica de 9562 casos endodônticos tratados por grupos heterogêneos com diferentes experiências clínicas. **Material e métodos:** Este estudo retrospectivo revisou os registros dentários de 8590 pacientes (9562 casos endodônticos e 13203 canais radiculares, incluindo 3340 canais radiculares de retratamento) tratados por graduandos do quarto ano, graduandos do quinto ano, estudantes do programa endodôntico e especialistas em endodontia, entre dezembro de 2017 e dezembro de 2018 no Departamento de Endodontia da Faculdade de Odontologia da Universidade Necmettin Erbakan em Konya. O comprimento, a densidade e a conicidade dos preenchimentos das raízes, a qualidade técnica aceitável dos critérios de preenchimento das raízes e a presença de erros processuais foram registrados. Os testes de qui-quadrado com nível de significância de $p = 0,05$ foram utilizados para análise estatística. **Resultados:** O preenchimento radicular aceitável foi encontrado em 71,5% dos casos endodônticos. A experiência clínica mostrou diferenças estatísticas na qualidade do preenchimento das raízes entre os alunos do quarto ano, do quinto ano, estudantes do programa endodôntico e especialistas (52, 63,1, 77,9 e 86,5%, respectivamente). Instrumentos fraturados e canais perdidos foram observados em 9,8% e 0,57% dos casos tratados pelos estudantes do programa endodôntico significativamente mais do que nas outras experiências clínicas. Não foram encontradas diferenças estatísticas entre as experiências clínicas em outros erros processuais. Não foram encontradas diferenças estatisticamente significantes entre faixa etária e sexo em canais radiculares adicionais. Foram observadas diferenças estatisticamente significantes entre o número de retratamentos do canal radicular em termos de faixa etária e sexo. **Conclusões:** A experiência clínica afeta a qualidade técnica dos tratamentos do canal radicular. Instrumentos fraturados e canais perdidos, especialmente por estudantes do programa endodôntico, devem receber mais atenção.

PALAVRAS-CHAVE

Radiografia dentária; educação; graduação.

INTRODUCTION

The main purposes of root canal treatment are disinfection, preparation, and hermetic obturation of the root canal system [1,2]. The possibility of an apical periodontal pathology is correlated with the quality of root fillings [3,4]. Although the results of endodontic treatment are generally evaluated by conventional radiography, clinical and histological evaluations may provide further assistance in cases of failure [5].

According to the European Society of Endodontology, adequate endodontic treatment includes exposure to preoperative radiographs, a defined working length, and radiographical control of the root canal filling [6]. The apical position of the root canal sealer material to the radiographic apex affects the success rate [4,7]. It has been reported that root canal fillings ending more than 2 mm to the radiographic apex and overfilling reduced the success rate [6]. In addition, gaps and voids in root canal fillings, particularly in the apical segments, are directly proportional to the prognosis of treatment [7,8].

Studies have shown that the technical quality of root canal treatment administered in Europe by general dental practitioners was weak [3,9,10]. Generally, dental practice, one of the reasons for such poor quality treatment, has been reported to be conducted by student graduates who lack expertise and have poor understanding of the principles. Endodontic epidemiological studies have been conducted in different population groups and reported the rate of acceptable root canal fillings to be 13%–76% [11-14]. In endodontics clinics of dentistry faculties, a case difficulty assessment should be used in student clinics for effective education and convenient treatment. For this purpose, the American Association of Endodontists (AAE) published

the “Endodontic Case Difficulty Assessment Form and Guidelines” to categorize endodontic cases as minimal, moderate, or high difficulty level (<http://www.aae.org/caseassessment/>). In studies conducted in recent years, the “Endodontic Case Difficulty Assessment Form and Guidelines” has been used as an auxiliary guide to general dentists and dental students [15-17].

No studies have been conducted on the incidence, quality, and success rates of root canal treatments performed in an endodontic clinic by heterogeneous groups with different clinical experiences, including dental school students, endodontic graduate program students, and endodontic specialists.

The aim of the study is to investigate the prevalence and management of endodontic treatment by heterogeneous groups with different clinical experiences in an endodontics clinic. The main objective is to identify factors that reduce the quality of treatment leading to better levels of dental education and treatment outcomes.

MATERIAL AND METHODS

The study protocol was approved by the ethical committee of the Necmettin Erbakan University Faculty of Dentistry (decision no: 2019/03), and it followed the recommendations of the STROBE statement for observational epidemiology studies [18]. This retrospective study reviewed the dental records of 8590 patients (9562 endodontic cases and 13203 root canals including 3340 retreatment root canals) treated by fourth-year undergraduates, fifth-year undergraduates, endodontic program students, and endodontic specialists between December 2017 and December 2018 at the Department of Endodontics of Necmettin Erbakan University Faculty of Dentistry in Konya.

The exclusion criteria of the dental records were patients aged under 15 years, edentulous patients, excluded preoperative and postoperative periapical radiographs, and unreadable periapical digital radiographs. The patients were divided into six groups according to age: 15–24, 25–34, 35–44, 45–54, 55–64, and ≥ 65 years old.

All teeth were categorized according to the AAE case difficulty assessment form as minimal, moderate, or highly difficult. According to the AAE Educator Guide, the minimal difficulty category is assigned a point value of 1, moderate difficulty is assigned a point value of 2, and high difficulty is assigned a point value of 5 (<http://www.aae.org/caseassessment/>). After summing up the points, less than 20 points and 20–40 points of root canal treatments were performed by fourth-/fifth-year undergraduate students using the step-back preparation and lateral condensation technique, respectively. About 20–40 points and above 40 points of root canal treatments were performed by endodontic program students/specialists using the nickel-titanium (NiTi) rotary system and the single-cone obturation technique, respectively. Root canal treatments were performed by fourth- and fifth-year undergraduate students under the oversight of experienced endodontists.

All clinicians attempted to access root canals following a straight line to the orifices and applied an initial glide path using a size 15 K-file. For the step-back preparation, stainless steel hand files were used, and the NiTi rotary files (Protaper Next-Dentsply Maillefer, Ballaigues, Switzerland; Revo S-Micro-Mega, Besancon, France) were used according to the manufacturer's instructions. The root canals were irrigated with 5.25% sodium hypochlorite and 17% ethylenediaminetetraacetic acid (EDTA).

In retreatment cases, the coronal, middle, and apical thirds of the root canals were retreated with Protaper Universal retreatment files according to the manufacturer's recommendations. After the removal of gutta-percha; Protaper Next, Revo-S, or stainless steel hand files were used as described above.

Each root canal treatment was examined with digital periapical radiographs (preoperative and postoperative). Periapical radiographs were obtained at 60 kVp and 7 mA using a Veraview X Type R Intraoral Digital Imaging Device (J Morita Corp., Osaka, Japan) and scanned with a Digora Soredex Phosphor Plate Scanner (Soredex Medical Systems, Helsinki, Finland).

The length, density, and taper of root fillings, the acceptable technical quality of the root filling criteria (Table I), and the presence of procedural errors as described by Balto et al. [11], were recorded. Two investigators examined the digital periapical radiographs independently. The results were compared, and a final agreement was reached. Otherwise, a third investigator was asked to read the digital periapical radiograph, and a final consensus was decided.

Table I - Summary of assessment criteria used for evaluation of the radiographs for the technical quality of the root filling (adapted with modification from Balto et al. [11]).

Variable	Criteria	Definition
Length of root canal filling	Acceptable	Root filling ending 0-2 mm from the radiographic apex
	Unacceptable	Over - Root filling ending beyond the radiographic apex Under - Root filling ending ≥ 2 mm away from the radiographic apex
Density of root canal filling	Acceptable	Uniform density of root filling without voids and canal space is not visible
	Unacceptable	Not uniform density of root filling with the clear presence of voids and canal space is visible
Taper of root canal filling	Acceptable	Consistent taper from the coronal to the apical part of the filling, with good reflect canal shape
	Unacceptable	Not consistent taper from the coronal to the apical part of the filling

Statistical analysis

The inter-auditor agreement was measured by Cohen's kappa (k) values. The obtained data were statistically analyzed using the chi-square test through SPSS Windows version 22.0 (Chicago, IL, USA). The significance level was set to $p = 0.05$. Simple descriptive statistics were used to describe the study population and the total number of root canals treated.

RESULTS

The k -value for the inter-auditor reliability was 0.85 for the acceptable technical quality of the root filling criteria and procedural errors. Acceptable root fillings were found in 71.5% (6838 endodontic cases of 9562 in total). Clinical experience showed statistical differences in the root filling quality among fourth-year undergraduates, fifth-year undergraduates, endodontic program students, and specialists (52%, 63.1%, 77.9%, and 86.5%, respectively) ($p = 0.000$, Table II). No statistical differences were observed in root filling quality between maxillary and mandibular teeth ($p = 0.62$).

The fourth-year undergraduate students showed better quality results in maxillary teeth ($p = 0.000$). No differences were found between maxillary and mandibular teeth for the fifth-year undergraduates and endodontic program students ($p = 0.327$ and $p = 0.109$, respectively). The specialists showed better quality results in mandibular teeth ($p = 0.000$, Table II).

Statistical differences were found in the root filling quality between fourth-year undergraduates and fifth-year undergraduates in all tooth locations except maxillary anterior

teeth ($p=0.169$). Statistical differences were observed in the root filling quality between endodontic program students and specialists in all tooth locations except mandibular anterior, maxillary premolar, and maxillary molar teeth ($p = 0.870$, $p = 0.053$, and $p = 0.073$, respectively, Table II).

Fractured instruments and missed canals were noted in 9.8% and 0.6% of cases treated by endodontic program students more than the other clinical experiences ($p = 0.000$, Table III). No statistical differences were found among the clinical experiences in other procedural errors.

Minimal or moderate difficulty levels of root canal treatments were made by fourth- or fifth-year undergraduate students in one, two, or three root canals. Advanced root canal treatments were usually performed by endodontic program students or specialists in three root canals or retreatments (Table IV).

No statistically significant differences were found between age range and gender in additional root canals ($p = 0.275$). Statistically significant differences were observed between age range and gender in the number of root canals ($p = 0.000$, Table V), with females aged 35–44 years showing the highest ratio (14.7%) and females aged ≥ 65 years showing the lowest ratio (2.4%) in the total number of root canals. Statistically significant differences were observed between the number of root canal retreatments in terms of age range and gender ($p = 0.002$), with females aged 35–44 years showing the highest ratio (17.6%) and females aged ≥ 65 years showing the lowest ratio (1%) in the total number of root canal retreatments.

Table II - Overall quality of root fillings in relation to the clinical experiences of the study in maxillary and mandibular teeth.

		Maxillary n (%)				Maxillary n (%)				Total n (%)
		Anterior	Premolar	Molar	Total of Maxillary	Anterior	Premolar	Molar	Total of Mandibular	
Fourth-year Undergraduate Students	Acceptable	384 (20.6)	359 (19.3)	1 (0.1)	744 (40)	91 (4.9)	119 (6.4)	13 (0.7)	223 (12)	967 (52)*
	Unacceptable	222 (11.9)	301 (16.2)	5 (0.3%)	528 (28.4)	77 (4.1)	253 (13.6)	35 (1.9)	365 (19.6)	893 (48)
	Total	606 (32.6)	660 (35.5)	6 (0.3)	1272 (68.4)	168 (9)	372 (20)	48 (2.6)	588 (31.6)	1860 (100)
Fifth-year Undergraduate Students	Acceptable	204 (9.7)	320 (15.2)	210 (10)	734 (34.9)	180 (8.6)	210 (10)	205 (9.7)	595 (28.3)	1329 (63.1)*
	Unacceptable	96 (4.6)	172 (8.8)	144 (6.8)	412 (19.6)	96 (4.6)	120 (5.7)	149 (7.1)	365 (17.3)	777 (36.9)
	Total	300 (14.3)	492 (23.4)	354 (16.8)	1146 (54.4)	276 (13.1)	330 (15.7)	354 (16.8)	960 (45.6)	2106 (100)
Endodontic Program Students	Acceptable	242 (6.9)	281 (8.1)	885 (25.4)	1408 (40.4)	109 (3.1)	240 (6.9)	959 (27.5)	1308 (37.5)	2716 (77.9)*
	Unacceptable	64 (1.8)	97 (2.8)	213 (6.1)	374 (10.7)	17 (0.5)	60 (1.7)	319 (9.2)	396 (11.4)	770 (22.1)
	Total	306 (8.8)	378 (10.8)	1098 (31.5)	1782 (51.1)	126 (3.6)	300 (8.6)	1278 (36.7)	1704 (48.9)	3486 (100)
Specialists	Acceptable	140 (6.6)	330 (15.6)	425 (20.1)	895 (42.4)	72 (3.4)	234 (11.1)	625 (29.6)	931 (44.1)	1826 (86.5)*
	Unacceptable	16 (0.8)	82 (3.9)	79 (3.7)	177 (8.4)	12 (0.6)	36 (1.7)	59 (2.8)	107 (5.1)	284 (13.5)
	Total	156 (7.4)	412 (19.5)	504 (23.9)	1072 (50.8)	84 (4)	270 (12.8)	684 (32.4)	1038 (49.2)	2110 (100)

*Significantly different relations.

Table III - Overall quality of root fillings in relation to the clinical experiences of the study in maxillary and mandibular teeth.

	Fourth-year Undergraduate Students	Fifth-year Undergraduate Students	Endodontic Program Students	Specialists	Total
Number of teeth	1860	2106	3486	2110	9562
Fractured instruments*	54	68	320	59	501
Ledge	13	20	6	3	42
Apical transportation	10	12	9	1	32
Apical Perforation	1	6	3	0	10
Root Perforation	5	4	3	0	12
Strip Perforation	0	7	1	0	8
Missed Canal*	0	5	20	4	29
Zippering	0	10	2	0	12
Furcation Perforation	0	6	0	0	6
Root Canal Straightening	0	5	1	0	6

*Significantly different relations.

Table IV - Descriptive statistics for the total number of root canals treated in relation to the clinical experiences of the study.

	Fourth-year Undergraduate Students	Fifth-year Undergraduate Students	Fourth-year & Fifth-year Undergraduate	Endodontic Program Students	Specialists	Total
Single Root Canal	1355 (35.4%)	858 (22.4%)	2213 (57.9%)	953 (24.9%)	657 (17.2%)	3823 (100%)
Two Root Canals	386 (24.2%)	367 (23%)	753 (47.1%)	576 (36.1%)	269 (16.8%)	1598 (100%)
Three Root Canals	54 (1.4%)	707 (18.5%)	761 (19.9%)	1881 (49.2%)	1183 (30.9%)	3825 (100%)
Additional Root Canals	8 (1.3%)	87 (14.1%)	95 (15.4%)	313 (50.7%)	209 (33.9%)	617 (100%)
Number of Root Canals Retreatment	58 (1.7%)	176 (5.3%)	234 (7%)	2216 (66.4%)	890 (26.7%)	3340 (100%)
Number of Teeth Retreatment	43 (2.7%)	149 (9.3%)	192 (12%)	869 (54.3%)	539 (33.7%)	1600 (100%)

Table V - Distribution of the root canals with age and gender.

		15-24	25-34	35-44	45-54	55-64	65 +	Total
Single Root Canals	M	223 (5.8%)	272 (7.1%)	304 (8%)	306 (8%)	305 (8%)	220 (5.8%)	1630 (42.6%)
	F	276 (7.2%)	380 (9.9%)	505 (13.2%)	469 (12.3%)	361 (9.4%)	202 (5.3%)	2193 (57.4%)
	Total	499 (13.1%)	652 (17.1%)	809 (21.2%)	775 (20.3%)	666 (17.4%)	422 (11%)	3823 (100%)
Two Root Canals	M	130 (8.1%)	186 (11.6%)	163 (10.2%)	124 (7.8%)	82 (5.1%)	34 (2.1%)	719 (45%)
	F	109 (6.8%)	205 (12.8%)	253 (15.8%)	193 (12.1%)	81 (5.1%)	38 (2.4%)	879 (55%)
	Total	239 (15%)	391 (24.5%)	416 (26%)	317 (19.8%)	163 (10.2%)	72 (4.5%)	1598 (100%)
Three Root Canals	M	366 (9.6%)	468 (12.2%)	466 (12.2%)	269 (7%)	153 (4%)	81 (2.1%)	1803 (47.1%)
	F	454 (11.9%)	491 (12.8%)	616 (16.1%)	285 (7.5%)	136 (3.6%)	40 (1%)	2022 (52.9%)
	Total	820 (21.4%)	959 (25.1%)	1082 (28.3%)	554 (14.5%)	289 (7.6%)	121 (3.2%)	3825 (100%)
Additional Root Canals	M	100 (16.2%)	87 (14.1%)	80 (13%)	38 (6.2%)	22 (3.6%)	9 (1.5%)	336 (54.5%)
	F	99 (16%)	59 (9.6%)	78 (12.6%)	28 (4.5%)	11 (1.8%)	6 (1%)	281 (45.5%)
	Total	199 (32.3%)	146 (23.7%)	158 (25.6%)	66 (10.7%)	33 (5.3%)	15 (2.4%)	617 (100%)
Number of Teeth Retreatment	M	115 (7.2%)	200 (12.5%)	183 (11.4%)	122 (7.6%)	61 (3.8%)	18 (1.1%)	699 (43.7%)
	F	187 (11.7%)	218 (13.6%)	281 (17.6%)	152 (9.5%)	47 (2.9%)	16 (1%)	901 (56.3%)
	Total	302 (18.9%)	418 (26.1%)	464 (29%)	274 (17.1%)	108 (6.8%)	34 (2.1%)	1600 (100%)
Number of Root Canals Retreatment	Total	696 (20.84%)	889 (26.62%)	973 (29.13%)	522 (15.63%)	203 (6.08%)	57 (1.71%)	3340 (100%)

M: male, F: female.

DISCUSSION

This study reviewed the root canal fillings of patients who were treated by operators with different clinical experiences, including fourth-/fifth-year undergraduate students, endodontic program students, and endodontic specialists.

The results showed that the technical quality of the root canal treatments performed by the fourth- and fifth-year undergraduate dental students was 57.9%. The success rate of endodontic treatments in different populations in terms of acceptable root canal fillings was

13% – 76% [11-14]. The success rates differed depending on the filling technique and the skills of the operator. In the Turkish population, the percentage of sufficient root fillings made by undergraduate students is 33% [19]. Previous studies have found that most students were not confident in performing molar endodontics and that they needed more experience [8,20]. In our endodontics clinic, undergraduate students performed the technical quality of root canal treatments better than those in other studies [8,20]. Thus, the AAE Educator Guide form could increase the success rate of fourth- and fifth-year undergraduate students to less than 20 points or 20–40 points.

Studies have reported some teaching problems related to undergraduate endodontic training in relation to academic staff shortages and lecture hours [8,12,21]. Undergraduate education on endodontics is provided by experienced endodontists at the dental school where this study was conducted. Undergraduates should complete a preclinical course for phantom patients in endodontics laboratories before beginning clinical root canal treatments in the first semester of their third year. The ratio of academic staff to students is approximately 1:3 for each class. Other studies reported this ratio to be 1:6 [8], 1:6 [12], 1:8 [22], 1:11 [23], 1:6 [24], and 1:4 [25].

In our dental school, endodontists have 9–18 years of experience in practice and have shown similar technical quality of root filling results (86.5%) to other studies [26,27]. Bierenkrant et al. [26] reported that the technical quality of root fillings by private specialist endodontists was found in 77.4%–91% of root canals. Other epidemiological studies undertaken in general practice or hospitals reported that the technical quality of root fillings was found in 49%–87% of root canals [27-31].

The introduction of rotary NiTi instruments has decreased procedural errors, such as root canal transportation, zipping, and ledge and apical perforation [26,32]. NiTi instruments also enable a consistent taper for a more reliable

preparation of root canals [26]. Our study showed that the endodontic program students made fewer procedural errors than the undergraduate students except for missed canals and fracture incidences of endodontic files, which led to their use of NiTi files and technical skills.

In this study, missed canals were found in 0.12% of undergraduate students. Balto et al. [11] reported that missed canals were found in 1.5% of undergraduate students. As Haug et al. [17] stated that endodontic mishaps were significantly higher in the high endodontic treatment difficulty level, this difference in ratio could be explained by the fact that simple root canal treatments had been performed by fourth- or fifth-year undergraduate students who achieved a minimal or moderate difficulty level of root canal treatments under the supervision of senior endodontists. This study showed that the fracture incidence of files was 9.8% in the endodontic graduate program. Other studies showed that the fracture events of rotary files were 0.82%–1.33% according to the number of root canals in an endodontic graduate program [33,34]. Nevertheless, these authors evaluated the number of rotary files that were fractured after a single use, without considering the teeth or root canals being treated. Thus, comparing the results of these studies was not appropriate. The significant incidence of fractures in this study can be explained by the skill level of the clinician, and clinical experience is a factor that may affect the incidence of fractured instruments.

The results of our study showed that the 9562 endodontic cases had 617 additional root canals in the anterior, premolar, or molar teeth. No statistically significant differences were found between age ranges and gender in terms of additional root canals. The 15–24 age range and men showed the highest ratio (32.3%) for additional root canals. In addition, only a few studies included information such as ethnicity, age, and gender of the study population, which could have significant clinical effects on treatment. Further CBCT studies are needed to determine the number of additional root canals in molar teeth. In the Turkish population, Sert and Bayirli

[35] reported that additional root canals ratio is 93.5% and gender is an important factor. Another study showed that no statistical differences were found in the frequency of additional root canals in molars according to gender [36]. In the Chinese population, no statistical differences were observed in additional root canals between age and gender, and significantly more additional root canals in upper molar teeth were performed on patients aged 20–30 years [37].

In our study, 1600 retreatment endodontic cases (including 3340 root canal retreatments), were conducted in the endodontics clinic by endodontics program students and endodontic specialists. Previous studies showed that the retreatment success rate was 79.5%–85.1% [38,39]. This study is limited by previous procedural errors and the clinician's skill level, which could have affected the final results. Nevertheless, there is a need to develop the technical quality of root canal treatments of undergraduate students by reviewing the educational program in endodontics.

Special attention should be given to the education methods and training of students who conduct root fillings in molar teeth using 3D in vitro plastic models. Fourth- and fifth-year undergraduate students should work on the minimal or moderate tooth difficulty level. Further investigations are needed to produce more positive results for the success of root canal treatments performed by undergraduate and endodontic program students.

CONCLUSION

Clinical experience affects the technical quality of root canal treatments. Educator Guide forms could increase the success rate of technical root canal quality. Fractured instruments and missed canals, especially by endodontic program students, should be given more attention.

Conflict of Interest Statement

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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